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The development of botany in Germany during the nineteenth century.

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AUTHORIZED TRANSLATION BY GEORGE J. PEIRCE.

[*Concluded from p. 204.*]

The new development which systematic botany has taken on in Germany during the last decades began when new life was given to morphology by its close union with the study of the cell, with anatomy, and embryology. Schleiden had already attempted in 1845 in his "Grundzüge der wissenschaftliche Botanik," in contrast to P. de Candolle, exhaustively to characterize the main groups of the vegetable kingdom in accordance with their morphology and development. He thus gave the method which is now being employed.

It was especially Alexander Braun and his school, however, who zealously sought to develop comparative morphology, especially of flowers and flower-clusters, and to make these available for systematic botany. Among the followers of Braun, Eichler made the most important advances in the development of the system by his "Blüthendiagramme" (1875-78). Eichler improved the system established by Braun, and gave in his Syllabus a review of the whole, and an arrangement which has since then formed the basis of most lectures on systematic botany at German and foreign universities, and which is followed in botanic gardens, collections, and herbaria. Systematic botany received a mighty impulse when, at the beginning of the sixties, Darwin's works re-established the theory of descent and won for it general recognition. The construction of a system based on phylogeny now became the ultimate goal of systematic botany, and the best means of attaining this was shown to be comparative morphology. The establishment of homologies, which alone can settle systematic relationships, was now striven after. Systematic botany immediately ceased to be limited by outward form, and brought to its aid internal structure also. The main groups were characterized with a view to their anatomy, and attention was given in due proportions, even in

the single systematic tribes, to a study of the different sorts of tissue and their different modes of formation. Hugo von Mohl and Anton de Bary, the founders of comparative anatomy, may be regarded as also the founders of the anatomical method in systematic botany, the value of which was then fruitfully recognized by the systematists themselves, especially by RADLKOFE^r (of Munich) in Germany, and before him, though not with such insistence on this point, by Engler, Count SOLMS-LAUBACH (Göttingen, Strassburg), and Pfitzer.

The most important German contribution of recent years to systematic botany is the work edited by Engler and PRANTL⁷ (Breslau) which has been in course of publication since 1889, "*Die natürlichen Pflanzenfamilien.*" Many, for the most part German, systematic botanists united to work up the material which has been accumulated in course of time and by their own exertions, and to give a uniform presentation of the numerous families of plants in accordance with the new points of view, combining comparative morphology, development, anatomy, and the results of biological research.

The systematic study of the cryptogams shows no less advancement during recent decades than that of the phanerogams. The algæ were especially worked up by TRAUGOTT KUETZING (teacher in Nordhausen) in his "*Tabulæ Phycologicae,*" published from 1845 to 1870 in twenty volumes, and in numerous other works; the fungi by P. MAGNUS (Berlin), G. WINTER (a scientific man in Leipzig who held no public office, and who died in 1887), and J. SCHROETER⁸ (high military surgeon in Breslau). We must thank the latter for a fungus flora of Silesia which is now nearing completion. The mosses received fundamental treatment at the hands of W. PH. SCHIMPER (Strassburg, died in 1880), and finally the vascular cryptogams by MILDE (Breslau, died in 1871) and LUERSSSEN (of Königsberg).

The study of plant-geography in the German Universities attained to greater importance first under GRISEBACH (Göttingen, died in 1879). His most famous work undoubtedly is "*Die Vegetation der Erde,*" which was published in two volumes in the year 1872. Grisebach considered climate to

⁷Died February 24, 1893.—G. J. P.

⁸Died December 12, 1894, leaving the flora still unfinished.—G. J. P.

be the most important factor in the distribution of plants. That there is, in addition to climate, a second and at least as important factor, namely the geological,—that, in other words, in order to understand the present distribution of plants, we must turn back to the floras and climatic conditions of former periods—was indeed admitted in principle by Grisebach though he scarcely noticed it in practice. This is readily explainable, since he regarded the species of plants as independent creations, and considered that variations in the species had only a limited and subordinate significance. On the other hand, the great excellences of the work were, that it gave for the first time a coherent presentation of the vegetable covering of the earth, that it divided the various floral territories into formations, and that it described the characteristic plants of each territory and formation. The later works of German investigators into the geographical distribution of plants, in contrast to those of Grisebach, are based on the theory of transformation, which here as elsewhere has shown itself to be extraordinarily fruitful. At the same time, the subject became divided into what may be called the geological or developmental, the systematic, and the biological sections. These do not antagonize one another but, on the contrary, supplement each other in giving a many-sided yet harmonious treatment of the whole.

The most important work in the geological section is by ENGLER (Kiel, Breslau, Berlin), published in two volumes in 1879 and 1882, under the title “Versuch einer Entwicklung der Pflanzenwelt.” In contrast to Grisebach, the author of this book puts the factor of development in the foreground, and seeks in the past history of the present flora, the explanation of many phenomena of distribution which cannot be accounted for by the present climatic conditions alone. The purely systematic direction, which concerns itself with the present conditions of the geographical distribution of plants, and seeks to define the limits of the floral kingdom, to mark the areas of species, is cultivated mainly in the Botanical Museum at Berlin, which contains the richest herbarium in Germany. Through the activity of our explorers and colonial officials, a mass of material, rich in African species, has been gathered together in recent years, which is now being worked up by Engler, with the assistance of other experienced botanists. The results up to this time

are published partly in Engler's "Ueber die Hochgebirgsflora des tropischen Afrikas," partly in his "Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie," which is the most important organ of this department of science. The flora of the German protectorate in southwest Africa has also been studied by SCHINZ (of Zürich). WARBURG (docent in Berlin) is the chief student of the flora of New Guinea, both as to its systematic and geographical aspects.

Still another important geographical undertaking is being directed at Berlin, namely the "Flora Brasiliensis," begun by VON MARTIUS (Munich, died in 1868), continued by Eichler, and now, under the direction of URBAN (sub-director of the Botanic Garden at Berlin), rapidly nearing completion. We are indebted for an important summary of the systematic geography of plants to a work published in 1884 by DRUDE (professor in the Institute of Technology at Dresden). By the same author, there appeared in 1890, a comprehensive "Handbuch der Pflanzengeographie" in which all parts of the field are uniformly treated.

The biological tendency in plant-geography, to explain the physiognomy of the single floras as adaptations to external conditions, was already visible in Grisebach's "Die Vegetation der Erde," but it has not received comprehensive expression. Single monographs, based on observations made in other than European countries, have been published in Germany by Schimper, Volkens, Schenck and Göbel. W. Schimper has done the most eminent work in this direction, and his experiences on his extended travels in the tropics are recorded in important and suggestive papers. The publication of these papers has followed since 1888 in the successive numbers of his "Botanische Mittheilungen aus den Tropen."

The means of aiding botanical investigation have increased remarkably in Germany during the last decades. Botanical laboratories which, in the fifties, did not exist at a single university, are now found at the agricultural schools and institutes of technology as well. The older botanists have brought about, and lived through, this transformation. De Bary, about whom in the sixties the majority of the young investigators gathered for further instruction, was the first to establish a botanical laboratory. At first at Freiburg, about 1858, it was in a low-studded room reached only by a steep dark stairway, where de Bary worked with his students Woronin,

Famintzin, and later Count Solms-Laubach. This laboratory was without separate endowment. Then, in the middle of the sixties, de Bary arranged a laboratory at Halle, roomy but as simple as possible in its arrangement, and quite unadorned. Finally, early in the eighties, he erected the laboratory at Strassburg, a handsome building, well adapted to advance scientific investigation, and expressing in its external appearance the great importance to which natural history had in the meantime attained.

Early in the sixties the botanical laboratories at Breslau, Munich and Jena were also built, and soon not only the other universities, but also other institutions of learning, followed their example. These laboratories now possess not only their own departmental libraries and the best optical instruments, but also the physical apparatus which physiological researches demand, and most of them have in addition small special green-houses connected with the buildings.

At most German universities⁹ two main courses of botanical lectures are given each year, in alternate semesters: the so-called general botany, which treats of the whole field of botanical knowledge, and is designed especially to meet the needs of the medical students; and special botany, in which all the groups of the vegetable kingdom are successively treated with a view to their morphology, and also generally as regards their physiological development. Together with these main courses, which are given by the full professors, others are given by the assistant professors and the docents, on the more important families of plants or on geographical botany, with practice in the determination of plants, some also on officinal plants and on pharmacognosy especially to meet the needs of the students of pharmacy. In the free courses¹⁰ subjects of more general interest, fertilization, pollination, adaptations, the more recent advances in the science, et cetera, are considered. Once a week, the professor or assistant professor is accustomed to conduct a botanical excursion. In the laboratory, generally twice a week, and each time for several hours in succession, there is given a practical exercise for beginners in which, at most universities, the important questions of histology are successively studied and the students are taught the use of the microscope

⁹A paper on the teaching of botany at German universities, by the translator, may be found in the *Educational Review*, January, 1895.

¹⁰For the others fees are charged.—G. J. P.

and the methods of micro-technique. For advanced students the laboratory is daily open, and there, under the direction of the teacher and his assistants, they attempt independently the solution of special problems.

Schleiden's "*Grundzüge der wissenschaftliche Botanik*" drove all other text- and hand-books from the field, and held for a long time its supremacy. The material to be worked over increased so remarkably during the forties and fifties, and so many new problems presented themselves, that it seemed indeed no easy task to bring everything together into a text-book. Schacht's "*Lehrbuch der Anatomie und Physiologie*," published in 1856, and Wilkomm's "*Anleitung zum Studium der wissenschaftlichen Botanik*," could not lay claim to having filled the gaps. This was first accomplished in 1868 by Sachs's "*Lehrbuch der Botanik*," which soon, in foreign lands as in Germany, gained the supremacy. The editions of this book followed in rapid succession, until Sachs refused to work the book over again. A summary of Sachs's text-book by Prantl, which in its successive editions adapted itself to the developments of the science, may be regarded as the text-book which is now most widely distributed among those who are learning the science. The number of such text-books has increased remarkably of late, and an exhaustive revision of Sachs's book has been recently undertaken by Frank.¹¹

The charts which now beautify the walls of almost every botanical lecture-room are indisputably important aids in teaching botany. Of these, certainly those by Kny are models. They were drawn either by himself, or under his direction, especially for teaching purposes, and were often preceded by special studies of the objects represented. The results of these investigations are presented in special pamphlets that serve at the same time as descriptions of the plates which they accompany. The wall-charts by Dodel-Port, and also those by Frank and Tschirch, are commendable and widely used. In most lecture-rooms microscopic preparations are demonstrated, and in many places, for example, at the University in Bonn, occasional hours are devoted to reviews, when the microscopic figures are projected by means of a solar microscope. In other places, the electric light is used for the same purpose, or the photogrammes by L. KOCH (of Heidelberg), are thrown upon the screen by the sciopicon.

¹¹This has now appeared in two volumes.—G. J. P.

Hugo Mohl was himself able to grind lenses. In various papers he instructed his contemporaries as to the manipulation of the microscope, and finally in his "Micrographia" gave exhaustive directions for its use. Schacht published a book on the microscope in 1862, whose chief value lay not so much in its optical part as in the directions for the study of specified vegetable objects. On the contrary, in Naegeli and Schwendener's "Das Mikroskop" the optical and purely physical portion of the subject was put in the foreground, while Dippel's work, "Das Mikroskop," published in 1867 and 1869, occupies the middle ground between the two preceding. Strasburger confined himself to the botanical part of the problem in "Das botanische Praktikum," which appeared in 1884 in a large edition for advanced students, and in a smaller one for beginners. This practical botany attempts to conduct the learner through a series of problems covering the entire field of microscopical botany, and to make him familiar with the use of the instrument and with microscopical technique. The structure and use of the microscope and botanical micro-technique are taught without the consideration of special objects for study by Behrens's "Leitfaden der botanischen Mikroskopie," published in 1890. His "Tabellen zum Gebrauch beim mikroskopischen Arbeiten," treat only of technique, and the same may be said of the "Botanische Microtechnique,"¹² by ZIMMERMAN¹³ (docent in Tübingen), published in 1892.

The numerous botanical journals now appearing give eloquent testimony to the activity of botanical research in Germany. "Flora" has been published since 1818 by the Botanical Society in Ratisbon.¹⁴ The "Botanische Zeitung" was founded in 1843 by Mohl and Schlechtendal. The "Jahrbücher für wissenschaftliche Botanik," for more comprehensive papers, have been published since 1858 by Pringsheim and are now before us in twenty-three constantly enlarging volumes. In the seventies most of the botanical laboratories of the German universities began to publish their researches in journals of their own. In addition, many botanical papers have been, and continue to be, published in the Nova Acta of the Leopold-Caroline Academy and in the Proceedings of other Academies. Since 1881 the "Botanische Jahrbücher für System-

¹²Translated by J. E. Humphrey, and published by Henry Holt & Co.—G. J. P.

¹³Now raised to the rank of assistant professor.—G. J. P.

¹⁴Edited since 1889 by Professor Karl Goebel of Munich.—G. J. P.

atik, Pflanzengeschichte und Pflanzengeographie" have regularly appeared under Engler's editorship, and have already reached the imposing number of thirteen volumes. It presently became impossible for any one to master the whole botanical literature, and so there was established in 1873 an organ for reviews, Just's "Jahresbericht," which appears yearly in two volumes and gives accurate abstracts of the contents of those botanical writings which have appeared in the course of a year. The "Botanisches Centralblatt," edited by Uhlworm, began in 1880, and is now completing its fifty-second volume. Owing to the enormous amount of material for publication, it has just been decided to issue supplements to this.

An important event in the life of botanical science in Germany was the founding, at Pringsheim's suggestion, of Die deutsche botanische Gesellschaft, of which Pringsheim has since been the President. German botanists, almost without exception, have joined this society, and many notable foreign botanists also, in addition to those who have been selected by the society as honorary or corresponding members. The society holds its regular monthly meetings in Berlin, the chairman of which is chosen yearly from among the Berlin botanists. A general meeting is also held each year, which until now has always been in conjunction with the Versammlung deutscher Naturforscher und Aerzte. The papers read or presented at the meetings are published in the "Berichte der deutschen botanischen Gesellschaft." A special commission under the chairmanship of C. ASCHERSON (Berlin), well known for his knowledge of the German flora, makes its yearly report on this subject at the general meeting. Der botanische Verein für die Provinz Brandenburg, also maintained in Berlin, especially cultivates the interests of systematic botany and publishes its proceedings.

The botanical laboratories, which soon became the centers of botanical work in the higher institutions of learning, at first somewhat overshadowed the botanic gardens in importance. Since then, however, most of the German botanic gardens have adapted themselves to the new problems of the science, and now actively supplement the physiological teaching by special displays of so-called biological groups of plants. The increasing interest in systematic botany has revived the interest in the plants themselves, and it is the botanic gardens

which aid one to form a conception of the most varied plant-forms of our globe. As experimental and acclimatization gardens they are now called upon to advance colonial interests, and have as their model the magnificent achievements in which the Botanic Garden at Kew, near London, may justly take pride. The botanic gardens must not be underestimated as a means of educating the general public; for it is by such establishments that our institutions of learning may keep in closest union with the unprofessional world which seeks further instruction.

The imposing edifice of the Botanical Museum at Berlin gives highly honorable testimony, as do the other museums established during the last ten years, to the noble efforts of the Prussian ministry. This botanical museum, scientifically arranged by Eichler, is now brilliantly developing under Engler's direction. It furnishes the center of fruitful opportunities for the growth of all botanical science in Germany, and, what will contribute not a little thereto, preserves for Germany the botanical treasures from foreign lands.

Bonn, Germany.

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